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THE HOWS AND WHYS OF LANDFILL ENTOMBMENT

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ABSTRACT

Investigations at Robins Air Force Base in Georgia identified an existing closed hazardous landfill as the source for active seeps of contamination into a stormwater channel. The landfill, closed in the mid-1960's, was used for general refuse disposal, laboratory chemical disposal, and fire protection training. Volatile organics, semi-volatile organics, pesticides and priority pollutant metals had high concentrations in soils and groundwater samples. Ground-penetrating radar was used to establish landfill boundaries since limited historical records were available. Soil borings confirmed underlying low permeability clay layers and high permeability sand lenses.

The unknown composition of the refuse, high concentrations of pollutants, environmental hazards and costs associated with removal led to the selection of complete encapsulation (entombment) of the landfill. Design of the entombment included a perimeter soil-bentonite cutoff wall, a two component barrier with a multi-layered cap, and leachate and methane gas collection. The underlying clay layer has a low laboratory permeability, below $1x10^{-7}$ cm/sec. The two component barrier consists of a bentonite mat and HDPE flexible membrane liner. This system was selected from alternative barrier designs for use as the low permeability infiltration barrier to meet RCRA requirements which state that the cap permeability must be less than or equal to the underlying soil. Long-term permeability and compatibility testing of bentonite mixtures for the cutoff wall with landfill leachate resulted in poor performance of certain bentonites. This led to selection of a sole source bentonite mixture. With entombment, leachate generation is expected to be minimal. However, leachate collection wells are provided to maintain an inward groundwater gradient within the cutoff wall and provide a way to measure excess infiltration from a cover breach or failure. Active gas collection is provided using perforated HDPE piping and a flare for off-gas control.

During construction, numerous problems occurred as a result of starting an aggressive construction schedule in the winter season. A slough of the slurry trench side wall caused concerns about sand lenses affecting the ability of the slurry to hold up the walls of the excavation. Due to the hydrogeological influence of an adjacent recreation lake and upgradient groundwater recharge area, a partial cutoff wall

("horseshoe") was used during soil preloading for preconsolidation of landfill wastes. This approach isolated the landfill hydrogeologically, allowing excess pore pressure caused by preloading to dissipate, minimizing risk of contaminant movement toward the lake and recharge area. Finally, problems with availability of the barrier layer material caused a switch in the liner material from Very Low Density Polyethylene (VLDPE) to High Density Polyethylene (HDPE). Material testing was critical since it uncovered deficiencies in the HDPE failing to meet industry standards.

The Air Force, in an attempt to save costs, suggested changes to the design which eliminated a gravel layer used for methane gas collection and in its place installing French drains. A geocomposite drainage layer was substituted for a 12-inch sand drainage layer. Subsurface drainage (above the barrier layer) was diverted to eliminate a gravity pipe system. Construction is nearly complete, and recent groundwater sampling results indicate successful achievement of objectives.

1. INTRODUCTION

The Warner Robins Air Logistics Center, located at Robins Air Force Base, Georgia, has conducted a series of investigations under the Installation Restoration Program (IRP). The purpose of the IRP is to identify and remediate sites on military installations that may have been contaminated during historical operations. Three sites were grouped together for investigative and remediation purposes and are further described as follows.

- Landfill No. 3 is a four acre area located immediately west of Luna Lake on the Base that received approximately 65,000 cubic yards of general refuse during its one year operation in 1964.

- Located within the boundaries of Landfill No. 3 is a second source of contamination, the Laboratory Chemical Disposal Area. This site reportedly consists of two unlined pits that were used for a one-time disposal of small jars and bottles of laboratory chemicals that had exceeded their recommended shelf life.

- The third source is Fire Protection Training Area No. 2 consisting of several open-burn sites using various flammable chemicals. These burn sites were located west and northwest of Luna Lake.

Subsequent site investigations of Landfill No. 3 employed groundwater wells, soil borings, electromagnetic conductivity surveys, electrical resistivity surveys, test pit excavations, and ground penetrating radar. These investigative techniques were used to determine the boundaries of each of the three disposal sites and identify the types and concentrations of the contaminants present. They indicated that the three individual sites are contiguously located in an area approximately six acres in size, immediately adjacent to the west shore of Luna Lake.

Analytical testing of soil and groundwater samples taken from the site indicate the presence of volatile organics, semi-volatile organics, heavy metals, and pesticides. The volatile organics present include dichloroethane, trichloroethane, chlorobenzene, toluene and xylene. The semi-volatiles discovered include dichlorobenzenes and dimethylphenols. Heavy metals determined to be present in concentrations higher than the maximum contaminant levels (MCLs) for drinking water include cadmium, chromium, and lead, with the pesticides DDE and DDT also present.

The Air Force has proposed a series of remedial actions to isolate and contain the site's contamination and prevent further migration to soil, surface water, and groundwater resources. These remedial actions include the construction of a sub-surface soil-bentonite cutoff wall, a multi-layer impermeable landfill cover, a leachate collection system, a methane gas collection and treatment system, and a groundwater dewatering system. These remedies are necessary for source containment. An integral part of source containment is the continued maintenance of an inward groundwater gradient across the slurry cutoff wall and maintenance of the final cover integrity.

2. PURPOSE AND NEED FOR PROPOSED ACTION

The purpose of the proposed action is to completely isolate and contain contaminants found in Landfill No. 3 and prevent migration into the underlying Providence and Blufftown aquifers. The Providence aquifer directly overlays (and is hydraulically connected to) the Blufftown aquifer, which serves as the primary drinking water source for the City of Warner Robins. The remedial activities would also eliminate current releases of contaminants into streams and creeks located down gradient from the site.

3. ALTERNATIVES CONSIDERED

Selection of the preferred course of action involves the comparison of alternative solutions on the basis of many factors. A variety of alternatives were considered, including:

- no action,
- removal and off-site disposal of the site's contaminants,
- In-situ treatment, and
- contaminant source isolation and containment (the chosen alternative).

The no action alternative was rejected because it would neither eliminate nor isolate the source of contamination that could eventually migrate to the underlying Providence and Tuscaloosa aquifers. The second alternative, excavation of the site's wastes and transportation to an off-site permitted hazardous waste disposal facility, was rejected for the following three reasons:

3.1 Safety

During excavation of unknown quantities of contaminated materials, site personnel would be exposed to chemical vapors and airborne contaminants. Although exposure can be controlled with personal protective equipment, releases of volatile organic compounds (VOC's) during excavation could reach lower explosive limits. This would create extremely hazardous working conditions and require immediate evacuation of both the site and surrounding area until escaped gases disperse.

3.2 Environmental Releases

Because engineering controls cannot fully prevent or contain VOC's released during excavation, transportation and disposal, quantities of VOC's would be released to the environment during these activities.

3.3 Costs

The cost of transporting and disposing of the wastes at the nearest permitted hazardous waste disposal facility were prohibitively high. Approximately 250,000 cubic yards of soil and landfill wastes would require disposal. The nearest permitted disposal facility is the Chemical Waste Management facility at Emelle, Alabama, approximately 310 miles away. In addition to the short term disposal costs, the Air Force's long-term liability associated with disposing of wastes in a hazardous waste landfill also contributed to the rejection of this alternative .

In-situ methods such as pump and treat or soil treatment were screened from consideration because of high costs and length of time to accomplish objectives. The proposed alternative of source containment was selected because it most effectively met the project criteria and was determined to be preferable to the other alternatives.

4. INTERIM MEASURES

The measures taken during the period between October 1993 and April 1996 are considered interim since immediate treatment of the migration of contaminants was necessary for protection of public health. In general, interim measures are typically expedited immediate response actions. The interim measures at the site precede additional work that is to be described in a Corrective Action Plan.

The interim measures implemented at Landfill No. 3 more specifically include the following features:

- Construction of a soil-bentonite cutoff wall with a permeability less than or equal to 1×10^{-7} cm/sec. Because the underlying soil has a permeability ranging from a high 3×10^{-7} cm/sec to a low 2×10^{-8} cm/sec, the slurry cutoff wall was designed within this range. The slurry cutoff wall, through its low permeability boundary, severs the hydraulic connection between Luna Lake and the landfill, and groundwater inside the landfill with groundwater outside the cutoff wall.

- Construction of a landfill cover composed of common soil fill, bentonite mat barrier, 40 mil High Density Polyethylene (HDPE) barrier, geocomposite drainage layer, engineering geotextile, topsoil, subdrains, and necessary surface grading. The purpose of the cover is to restrict rainfall infiltration from the surface. Environmental Protection Agency guidelines for RCRA sites suggest the permeability of the cover be less than or equal to the underlying soil. Permeability of this cover is expected to be substantially less than that of the underlying soil.

- Construction of a permanent leachate collection system including extraction wells, submersible pumps, double containment pipes, wet well, dry well and controls. Because the effectiveness of the source control requires an inward groundwater gradient through the slurry cutoff wall, leachate removal is needed. Leachate is collected and removed from the site via the leachate extraction system.

- Construction of a landfill gas venting system including screened gravel trenches, HDPE perforated collection pipes, 40 cubic feet per minute (SCFM) positive displacement blower, condensate removal, landfill gas combustion flare, vent stack and controls. This system is to remove and treat methane and other landfill gases that pocket under the landfill cover causing premature degradation of the cover.

- Soil preloading for preconsolidation of the landfill. Preloading was included to mitigate the effects of settlement, and to reduce the uncertainties inherent in estimates of landfill cover integrity after the cover is placed in service.

5. RESULTS OF DESIGN, TESTING AND EVALUATION

5.1 Test Pits

Bulk soil and groundwater samples were collected from three test pits excavated by backhoe along the alignment of the slurry cutoff wall. The samples from each pit were collected for use in bentonite design mix tests and compatibility tests. Samples were tested for target compound list organics, semi-volatiles, pesticides, PCB's and target analyte list metals.

5.2 Compatibility Testing.

A series of tests were conducted to determine the compatibility of bentonite with landfill leachate. The objective was to design a stable bentonite slurry mix for trench wall construction and optimum backfill mix for the cutoff wall. Various sources of bentonite were mixed with contaminated water and soil from the landfill and tested for physical stability, flocculation and long-term permeability. Initial results from the tests showed a strong reaction between the contaminated site water and several of the bentonites tested. However, a proprietary product, "Saline Seal" from American Colloid produced an acceptable slurry with satisfactory long-term permeability, viscosity and no flocculation. Thoroughly mixed site soils with 4% Saline Seal sufficiently yielded permeabilities of less than 1×10^{-7} cm/sec in the laboratory. Design of the field mix was established using 5 to 6% Saline Seal. Since thorough mixing is difficult and expensive to accomplish in the field, the increase in volume of bentonite was necessary to achieve similar field results to laboratory test results.

5.3 Groundwater

Throughout construction of the interim measures, groundwater levels within the confines of the slurry cutoff wall were monitored. Prior to implementation of the interim measures, groundwater in the landfill was hydraulically linked to the flow of water seeping from Luna Lake. After construction of the slurry cutoff wall along the Lake side of the landfill (east side), the hydraulic connection was severed. There was concern that groundwater would rise due to reduction of pore volumes in the soil caused by preconsolidation of the landfill, especially with the cutoff wall installed. Since the groundwater was contaminated, maintaining the water surface level in the landfill below the top of the slurry cutoff wall was required to prevent an uncontrolled release of contaminated liquids onto the ground surface. By partially constructing the cutoff wall (leaving one side open similar to a 'horseshoe'), excess pore pressure caused by soil preloading was expected to dissipate out the open end. However, a slough of the slurry trench side wall during construction caused the horseshoe wall to remain open in an area which limited groundwater movement. Groundwater elevations then became influenced by frequent rains and by recharge from a swampy area south of the landfill. At conclusion of the slurry cutoff wall in May 1994, the groundwater level in the landfill approached within two feet of the top of the cutoff wall and remained there until the cover was completed.

5.4 Landfill Gas Sampling

Five air samples were collected from the landfill gas collection system. The samples were analyzed for volatile organic compounds and for methane. A number of chlorinated volatile compounds, hydrocarbons and freon compounds were detected at significant concentrations in all five samples. The highest concentrations of chlorinated compounds were cis-1,2-dichloroethene and vinyl chloride. Concentrations of cis-1,2-dichloroethene ranged from 2,900 to 780,000 ppbv, and vinyl chloride ranged from 540 to 91,000 ppbv. Methane was detected in significant concentrations ranging from 24,000 to 530,000 ppmv. Gas concentrations represent static, confined conditions.

5.5 HDPE Flexible Membrane Liner

Testing to confirm the characteristics of the flexible membrane liner installed at the site was conducted. Several samples were tested at the point of manufacture and rejected for failure to meet strength and elongation requirements. After testing material from several manufacturers, the material ultimately used for the liner proved to be consistent with the industry standard requirements for 40 mil HDPE.

6. CHANGES MADE DURING DESIGN

As in any construction project, field conditions or economic conditions often influence the implementation of the design, resulting in field modifications. Significant changes that were implemented and their affects on the design are outlined below:

- The flexible membrane liner material was modified. During the course of construction, the cost for VLDPE increased significantly and supplies became unavailable. Substitution of a 40 mil thick HDPE liner for the originally designed 40 mil thick Very Low Density Polyethylene (VLDPE) liner was made.

- The screened gravel layer for the gas collection system was eliminated. Instead of a gravel layer over the surface of the landfill, several smaller collection trenches, filled with No. 57 crushed stone aggregate, and similar to the design of a French drain, were used. This trench system, in lieu of the screened gravel layer, was used primarily to achieve cost savings. The trench collection system, although not as effective as the screened gravel layer, is still an acceptable method for gas collection.

- The 12-inch sand drainage layer above the flexible membrane liner was replaced with a thin geocomposite drainage layer. The advantage of the sand layer over the geocomposite was additional soil moisture storage that could be used to support surface vegetation. Cost savings was a controlling factor in this decision.

- The soil cover above the geocomposite drainage layer was reduced from 24 inches to 15 inches. Due to cost considerations, the grading surface was not brought to the elevations as designed. A disadvantage of this decision is that a healthy stand of vegetation may not survive during dry, hot weather periods. Insufficient retained soil moisture in the cover may not support the growth of desirable vegetation.

- Due to project cost growth, the perimeter subdrainage system was also eliminated. Elimination of this system affects the ability of the geocomposite drainage layer to rapidly remove surface water from above the flexible membrane liner. Over many years, water ponding on the surface of the flexible membrane liner may act to weaken the liner, possibly resulting in a rupture. Without the subdrainage piping, runoff from the drainage composite layer must seep through cover soils to drain off the landfill.

7. EFFECTIVENESS OF THE INTERIM MEASURES

Recent analytical data from groundwater well samples from fall 1994 through spring 1996, represent the first concentration measurements with the slurry cutoff wall in place. Groundwater samples taken from wells located adjacent to (outside) the cutoff wall have exhibited significant decreases in contaminant concentrations. The reductions indicate that the cutoff wall has effectively contained hazardous contaminated groundwater within the landfill and allowed uncontaminated groundwater to begin to purge these locations. Continued monitoring will determine if decreasing trends are likely to continue.

8. CONCLUSIONS

Remedial measures were implemented to control the source of hazardous levels of groundwater contamination at Landfill No. 3, Fire Training Area No. 2 and Laboratory Chemical Disposal Area on Robins Air Force Base, Georgia. Source isolation and containment were selected which includes installation of a slurry cutoff wall, a landfill cover, and leachate and gas collection systems. Interim measures were initiated in October 1993 and completed in April 1995. As of spring 1996, sampling data indicate that concentrations of hazardous substances in the groundwater outside the cutoff wall are reducing. The remedial measures are demonstrating effectiveness in containing the contaminant source and controlling migration of pollutants into the environment. With firm establishment of vegetation and wild flowers on the surface of the landfill, the site has been effectively returned to non-intrusive recreational use.